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NECESSARY AREAS OF ARCTIC
BUILDING RESEARCH

by

George JACOBSEN

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NECESSARY AREAS OF ARCTIC BUILDING RESEARCH

George Jacobsen*

Conditions on Arctic engineering and construction projects are different in several aspects from similar projects in the South.

The main differences are a severe climate characterized by short cool summers with many hours of daylight and long cold winters with long hours of darkness, periods of high winds, great distances from sources of supply (with the inherent high cost of transportation), isolation of individual projects or settlements and last but not least the frozen ground (permafrost) which covers the whole area in depths from 2 to about 950 meters.

All these parameters influence human settlement and activity in many direct and indirect ways. Up to World War II buildings in the Arctic were of the simplest kind. Southern

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* Arctic Consultant, The Tower Company (1961) Ltd., Montreal. Prepared for Colloque Direction Nord, November 20th. and 21st., 1975, organized by Le Centre d'Ingénierie Nordiques de l'Ecole Polytechnique de Montréal and Centre d'Etudes Nordiques de l'Université Laval.

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shelters transferred to the Arctic and often badly and hastily built by unskilled traders, policemen or missionaries who had to rush construction in the short period between the arrival of the supply ship often in late August or even September and the onset of winter, to get a roof over their head before the really cold weather started.

Knowledge of insulation was sketchy and often consisted of tarpaper, moss or even sawdust. Foundations were either sills on the ground or on rocks or wooden post foundations. Most of these buildings moved up and down with the freezing cycle of the ground and the yearly jacking up of buildings was a regular spring chore with which Hudson's Bay managers and other Arctic inhabitants who lived in wooden houses were very familiar.

World War II and the years after brought air bases, meteorological, scientific and defence installations into the Arctic, but most significant of all was the growth of sizeable settlements occasioned by the administrative and welfare activities of the federal government or in some case by resource extraction industries. These settlements received newcomers from the South who required bigger, warmer and more sophisticated buildings with a modicum of sewer and water services.

The coal heated white clapboard house with the red or green trim of the trader, policeman or missionary was replaced by the oil heated prefabricated plywood house. - As a side remark it might be interesting to mention that the use of plywood as a building material is comparatively recent. It only became a common building material in the South a few years after World War II during which weatherproof plywood was developed for the manufacture of the Mosquito aircraft.

During the last three decades much was learned about Arctic construction by research and by trial and error. Sizeable concrete, steel and frame structures covered with anodized aluminium or steel or fibreglass panels were built, sewer and water systems, paved roads, airports, mines and dams were constructed which on the whole served these isolated communities quite satisfactorily. However much was achieved at inordinate cost and was of imperfect design.

We shall now consider where applied research could improve our technical and economic performance in areas of Northern construction. By doing this we should bear in mind that in most places in Southern Canada we too live four to five months in an Arctic climate and any design or technology which

improves our Arctic building technique will probably in some way, also benefit construction in the southern part of our country. [When allocating research priorities consideration must be given that the design of Arctic structures and settlements will be socially satisfactory to the heterogeneous population of these very recent communities and instant towns, a population which is millenia apart in their backgrounds and is outwardly held together by the technological lifestyle of the twentieth century and by a necessary territorial administration.] In these settlements the autochthonous people go through the shock and confusion of their cultural transition. They are forced, by the fact that they live in a settlement, to give up their old values and are unable or unwilling to accept the new ones. On the other hand, the majority of southerners who come to the Arctic are transients who are often unhappy about their displacement, a fact which further contributes to the uncertainty of the social climate in these communities.

[To produce a satisfactory design of buildings and community for these conditions alone is indeed a formidable task but the design must also be economic, comfortable, technologically sound and aesthetically pleasing.]

What are then the areas of research which could help us most achieve these requirements and improve the present state of the art?

Site surveys and foundation design come first to mind. A great deal of knowledge is available and various techniques have been developed to calculate and construct solid foundations in permafrost areas. However both in siteing of buildings and communities and in foundation design much more research is needed. Site surveys contain many parameters and cannot be reduced to linear equations. As in the foreseeable future settlements in the Arctic will be small communities from a few hundred to a few thousand people, research is needed to develop systems which would feed parameters weighted for such small settlements into a computer and come out with the best possible solution.

To illustrate this we shall take the parameters of snowfall and snowdrifting. In a city like Montreal really nothing can be done about it. If in one year it snows and blows more than normally, just more equipment has to be employed and the cost of snowclearing and the city taxes go up.

In the Arctic however one can site a new small settlement in such a manner that snow drifting will be held to a minimum. In some such cases the comfort factor might be

reduced, but people will be able to circulate freely in the settlement (particularly important in case of fire) and the cost of snowclearing will also be drastically reduced.

A case in point is the new town of Resolute. The designer had the choice to site the town either on a beach ridge from which the snow was usually blown away or in a protected hollow. He chose the snowy hollow putting - in my opinion - too much emphasis on the comfort factor with the result that by this date at the beginning of winter the town has already spent most of its snow clearing budget for the whole winter. I do not want this to be understood that the human comfort factor should be neglected but one has to be aware of the living habits of the high arctic people. They do not wander around in a snowstorm be they on a ridge or a hollow. They move mostly in closed vehicles and it is more important that the roads are passable for these vehicles than that the odd pedestrian is exposed to less wind.

Some other important parameters which would have to be fed into this computer model would have to be, sewer and waste disposal (straight outfall, lagoons, chemical treatment, re-circulating or collection from holding tanks in individual houses, etc, water intake (sources, treatment, distance or hauling), roads (insulation and drainage), engineering

implications of ground water flow, stability of slopes, distance of airfield from settlement, etc. The model could be made as big or as small as desired. It would be probably desirable to make it as simple as possible and consider the other parameters outside the model. The most important thing is that the designer has arctic living and working experience, is conversant with the extensive existing literature and is not an armchair arctic expert who sets out to re-invent the wheel.

Foundation loads can be calculated with linear equations and considerable research is being done by private and government agencies on their performance and on such topics as strength and deformation characteristics of frozen ground, frost heave characteristics, settlement and consolidation.

Research in this line should concentrate on easily adjustable foundation systems for light structures. Either lightweight steel grids or wood systems with adjustable jacks for mat foundations or centre bearing piles with cantilever beams. In settlements with no sewer and water systems, and they are in the majority, a prefabricated combination foundation - sewage - water and storage area between 2'6" - 3'-6" high would be a most useful housing component. Service areas under houses are nothing new, the first having been built by the writer in 1951 (Nursing Station, Hall Beach, N.W.T.), but an insulated, folding

prefabricated service foundation could eliminate a lot of cost and save construction time at the site.

The sewage and water problem as a whole is still a vast field of research. It involves geothermal considerations, all the properties of and characteristics of frozen ground, drilling, blasting and excavating in frozen ground, frost heaving, the large and ecological important field of waste disposal and last but not least a good deal of mechanical ingenuity.

Many good systems exist here and in other polar countries. The larger the installations are the more efficient the systems usually become. Steam leaking, electric heating, circulating water and in a few cases waste exhaust are utilized to keep the systems from freezing. They also must be accessible for repair and maintenance in all weather conditions which means either the construction of manholes in permafrost or surface structures which are not liable to be drifted in completely. The Tower Company of Montreal has designed a streamlined structure which when properly sited does not drift in completely and allows quick access to utilidors near the surface or through manholes to deep service systems. These same structures contain the firefighting equipment and connections. They are evenly spaced along the service line

and enable the firefighting equipment to be connected quickly in case of emergency.

All these larger systems have one thing in common. They are expensive and only big settlements can afford them. Much research could be done here to improve performance and cost. Areas of research would be lightweight packaged prefabricated systems in certain lengths, which could be easily connected to one another in the field, the use of new pipe materials, better insulating methods and materials, automatic fail safe devices in case of freezing and the most economic way to heat these systems.

The disposal of the raw or treated sewage is another field where the arctic environment poses problems. Where a treatment plant can be built and the effluent discharged into the sea, lake or river there are no problems. Where this is not available icing conditions will occur which need careful considerations and study. The real problem is the untreated sewage which can either be fed via a septic type holding tank, or directly into a sewage lagoon. In some places like Frobisher raw sewage is directly fed into the sea. Sewage lagoons work satisfactorily in the Arctic if they are installed with knowledge and intuition. But much research could be done here.

In communities without sewer and water systems a need for self contained toilets exist. There are several models on the market of either the chemical, refuse burning or the flush type. Of the latter a model which uses mineral oil as flushing agent seems to hold some promise. The whole field of a service package for a house in unserviced communities needs intensive research. If it could be combined with a wind generator which would supply part or all of the energy much will have been achieved.

Wind power does not fall into the category of building research, however there is no doubt that in the next decades it will be part of our energy supply. The presently available and the future generation of probably much improved wind energy machines have great possibilities for small communities and arctic stations. A development which also would have wide application in other sparsely settled parts of Canada.

Most arctic family dwellings are prefabricated plywood and metal clad frame dwellings. On the whole they are warm and comfortable but much research could be done on design with new lightweight materials, layouts and construction details.

The design of plans is done in the south. It should be done in the north with the help of indigenous people. Eskimos and Indians have different lifestyles and requirements from southern Canadians. Different communities will probably come up with different designs. Not all of them will be good or practical. The mere fact that one is an Inuit or Indian and lives in the north does not mean that one is a good house designer, but the northern people should have an input of their ideas. This will not only produce diversified and satisfactory housing from which some good northern designs will develop, but it is socially desirable. Even if houses are prefabricated there is no reason why they have to be stereotyped.

Construction details which should be researched are roofs and roofing for large and small structures with particular attention to flat roofs for large structures. At the present time no satisfactory built up roof is available by the fact that no roofer will give a guarantee on a built up tar and gravel roof in the arctic. Carefully designed eave and curb details for any kind of roof are of greatest importance as fingerlift action of the wind starts at this point. An example of what can happen is the part of the Frobisher Arena

roof which blew off in a comparatively mild windstorm of about 45 miles per hour in 1974. The damage started at a point of the eaves where some bolts had been countersunk too deeply into the wood with the result that the wood was not strong enough to hold. The strong uplift force of the wind tore the wood away and with this purchase took half of the roofing away doing about $60,000.00 worth of damage.

For sloping roofs, shingle roofing has the disadvantage that it needs warm weather to be well applied. Althoughly widely applied in housing and smaller structures they are not ideal. Heavy galvanized steel roofs or anodized aluminium roofing with a minimum of overhang have the best performance record.

From the snow blocks of the igloo to the polyurethane panel of the modern structure insulation has made it possible for man to live in the arctic. We have a variety of insulating materials and methods available, but there is ample room for more research.

Other fruitful fields of research are ventilation, moisture control, windows, doors and arctic hardware. Particularly the latter is a field in which very little has

been done. The little which has been done is not really innovative but a modification of southern hardware. Again this is a field where research results would also be useful in the south.

Transportation costs on arctic projects run between 12% - 20% of the total job costs. Proper crating and packaging to achieve the lightest weight and the smallest volume are therefore highly important. Lightweight and low volume design of all components and stacking, packing and crating research can substantially reduce the cost of a project.

One could go on for a long time over the areas which need further research. There is ample room for basic innovation and improvement of existing designs and practices in the field of northern building. One must not forget however that engineering is also an economic science and cost must not become disproportionate to the results achieved.

Finally no design however solid, functional, practical and inexpensive is any good if it does not take full account of the human factor because that is what it is all about.

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